

# Corneal surgically induced astigmatism in resident surgeons

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## ABSTRACT

To evaluate surgically induced astigmatism (SIA) in resident surgeons in their first year of performing cataract surgery, a retrospective study was conducted involving three resident physicians from July 1, 2019, to June 30, 2020. Preoperative and postoperative corneal measurements were taken with the IOLMaster 500 and Pentacam. Mean SIA and centroid were determined with the Koch-Wang Excel spreadsheet. A total of 135 eyes were operated on, with Resident A performing 67 surgeries; Resident B, 60 surgeries; and Resident C, 8 surgeries. Resident A's IOLMaster results revealed centroid values of 0.08 D @ 91° ± 0.37 diopters (D) and 0.16D @ 82° ± 0.32D and Pentacam centroid values of 0.13D @ 100° ± 0.34D and 0.24D @ 93° ± 0.38D for right and left eyes, respectively. Resident B's IOLMaster results revealed centroid values of 0.23D @ 102° ± 0.23D and 0.29D @ 110° ± 0.26D and Pentacam centroid values of 0.21D @ 124° ± 0.33D and 0.17D @ 103° ± 0.51D for right and left eyes, respectively. In conclusion, centroid values of SIA with junior surgeons were more than the proposed established values, but likely not clinically significant, with at most a difference of <0.17D in the spectacle plane. To achieve more accurate refractive outcomes in toric intraocular lenses, all residents should calculate their personal SIA early in their surgical career.

**KEYWORDS** Cataract surgery; centroid; surgically induced astigmatism

Cataract surgery is the most common procedure performed, with over 3.6 million surgeries performed in 2015 alone.<sup>1</sup> With improvements in intraocular lens (IOL) calculations and newer-generation formulas, 94% of patients achieve best corrected visual acuity of 20/30 or better, and 72% to 80% of patients end up within 0.5 diopters (D) of emmetropia.<sup>2,3</sup> Surgically induced astigmatism (SIA) represents the amount of astigmatism created by the main wound construction. Several factors contribute to the amount of SIA created, such as length, width, location, and structure, with the width of the incision being the most influential.<sup>4–6</sup> Abulafia et al found that the centroid value, the mean SIA magnitude and direction, can produce an SIA of around 0.1D as opposed to the traditional 0.35D.<sup>7</sup> Junior surgeons typically lack the consistency and reproducibility of surgical approaches and wound outcomes compared to experienced surgeons. We were not aware of studies showing SIA outcomes by surgeons in training. This study assessed the amount of SIA of junior surgeons during early stages of training.

## METHODS

This retrospective case series comprised a total of 135 eyes. All patients were operated on between July 1, 2019, and June 30, 2020, by second-year (postgraduate year 3) residents at the Central Texas Veterans Affairs Medical Center (VA). The study protocol followed the guidelines of the Declaration of Helsinki as well as the VA institutional review board. No consents were obtained, as the retrospective chart review posed minimal risk to patients and obtaining informed consent was not feasible, as many of these patients were no longer followed at the Temple VA. Preoperative keratometry and axis measurements were taken with the Zeiss IOLMaster 500 and the Oculus Pentacam. All surgeries were performed using 2.4 mm clear cornea incisions at a temporal position. Sutures were placed through the main wounds only in cases of wound leaks after adequate corneal hydration. In the instance of suture placement during cataract surgery, postoperative measurements were taken at least 3 weeks after suture removal; 4 to 6 weeks following cataract surgery, postoperative keratometry and axis measurements were repeated with IOLMaster 500 and

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Pentacam. The three residents were designated by the order (A, B, and C) in which they rotated at the VA Medical Center. Patient demographics were obtained, including the age at the time of surgery and gender.

Centroid and mean SIA were calculated using the Koch-Wang Excel spreadsheet available on the American Society Cataract and Refractive Surgery website.<sup>8</sup> Data included the preoperative flat K, flat axis, steep K, and steep axis and postoperative flat K, flat axis, steep K, and steep axis. The data were split between right and left eyes. The results from the IOLMaster 500 and Pentacam were compared for any significant differences using a one-tailed unpaired *t* test. An unpaired *t* test was used since not every patient was able to obtain both forms of keratometry measurements.

Patients were excluded from the study if they were lost to follow-up or if a postoperative keratometry measurement was not performed. Other exclusion criteria included unreliable preoperative or postoperative keratometry measurements due, for example, to corneal scars or eyelid obstruction. Patients with any significant complications, such as endophthalmitis or ruptured posterior capsule, were also excluded.

### RESULTS

From July 2019 through June 2020, Resident A performed 67 cataract surgeries, Resident B performed 60

cataract surgeries, and Resident C performed 8 cataract surgeries. Resident A operated on 36 right eyes (53.7%) and 31 left eyes (46.3%); Resident B operated on 28 right eyes (46.7%) and 32 left eyes (53.3%); and Resident C operated on 5 right eyes (62.5%) and 3 left eyes (37.5%) (*Table 1*).

Of the 67 cataract surgeries performed by Resident A, 58 (33 right eye, 25 left eye) postoperative IOLMaster corneal measurements were taken. *Figure 1* shows the double angle plot of the centroid values. Besides the 8 patients (8 eyes) lost to follow-up and the one patient unable to obtain IOLMaster measurements, no other patients were excluded from the Resident A data set. No significant complications were reported by Resident A.

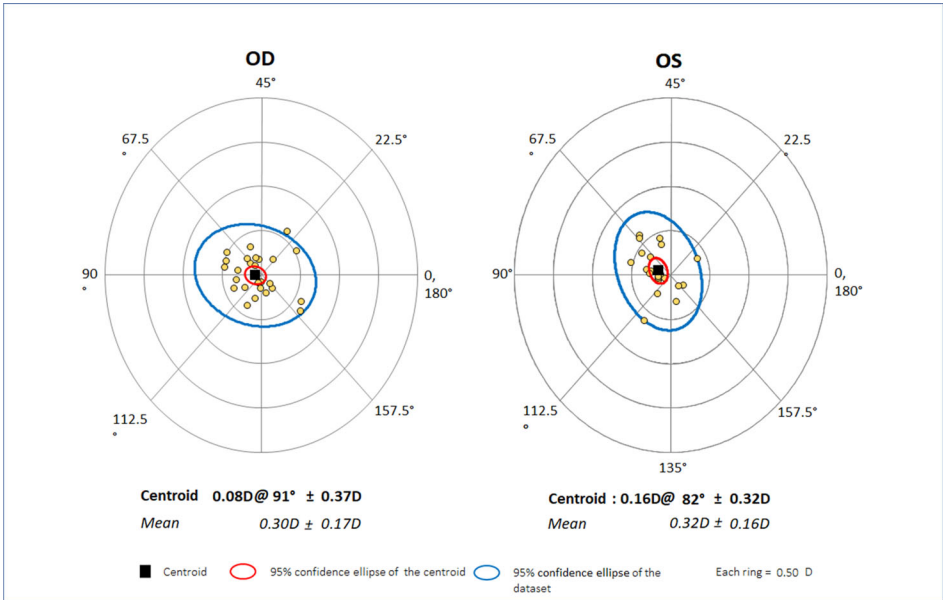
Of the 60 cataract surgeries performed by Resident B, 27 (10 right eye, 17 left eye) postoperative IOLMaster corneal measurements were taken. *Figure 2* shows the double angle plot of the centroid values. Eighteen patients (24 eyes) were lost to follow-up, with another 5 patients (9 eyes) unable to obtain IOLMaster measurements due to the IOLMaster undergoing repairs. One patient was excluded for wearing contact lenses during preoperative measurements. No significant complications were reported by Resident B.

Due to COVID-19 elective surgery shutdowns at the VA, Resident C operated on 8 patients, with none returning for postoperative measurements. All 8 were thus excluded, and the results from Resident C were not included in the study. There were no significant complications reported by Resident C.

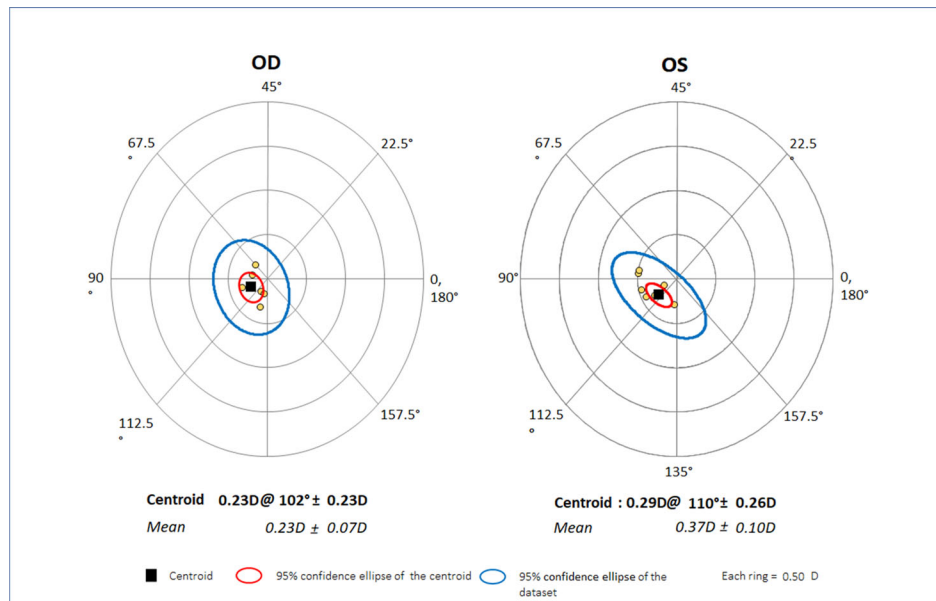
*Table 2* shows the overall results of the study: IOLMaster centroid means ranged from 0.08D to 0.29D; IOLMaster mean SIA, from 0.23D to 0.37D; Pentacam centroid, from 0.13D to 0.24D; and Pentacam mean SIA, from 0.27D to 0.42D. The unpaired *t* test showed no significant difference between the IOLMaster centroid results and the Pentacam centroid results for both right eyes and left eyes, and no

Table 1. Patient demographics for Residents A, B, and C

Resident	Average age	Male	Female	Right eyes	Left eyes
Resident A	75	62	5	34	33
Resident B	74	57	3	28	32
Resident C	69	8	0	5	3



**Figure 1.** Resident A double angle plot of centroid values and mean surgically induced astigmatism for both eyes from the IOLMaster 500.



**Figure 2.** Resident B double-angle plot of centroid values and mean surgically induced astigmatism for both eyes from the IOLMaster 500.

**Table 2.** SIA values calculated from the IOLMaster and Pentacam for residents

Resident	Eyes	IOLMaster		Pentacam		P value	
		Centroid	Mean SIA	Centroid	Mean SIA	Centroid	Mean
A	Right	0.08 @ 91° ± 0.37D	0.30D ± 0.17D	0.13D @ 100° ± 0.34D	0.27D ± 0.17D	0.57	0.48
	Left	0.16D @ 82° ± 0.32D	0.32D ± 0.16D	0.24D @ 93° ± 0.38D	0.41D ± 0.19D	0.42	0.07
B	Right	0.23D @ 102° ± 0.23D	0.23D ± 0.07D	0.21D @ 124° ± 0.33D	0.30D ± 0.11D	0.87	0.09
	Left	0.29D @ 110° ± 0.26D	0.37D ± 0.10D	0.17D @ 103° ± 0.51D	0.42D ± 0.24D	0.38	0.43

SIA indicates surgically induced astigmatism.

significant difference between mean SIA results for both right and left eyes.

## DISCUSSION

As cataract surgery has become technologically more advanced, the correction of astigmatism has become ever more important. Factors influencing the correction of astigmatism include but are not limited to SIA, preoperative keratometry measurements, lens rotation, and the accepted range of manufacturer error of intraocular lenses. As beginning surgeons learn the intricacies of operating and wound creation, it is expected that there is less reproducibility in clear corneal incisions than that of experienced surgeons. As reported by Abulafia et al, the centroid value of 0.1D should be used instead of the traditional mean SIA of 0.35D.<sup>7</sup> Significant ocular surface disease may result in >0.5D refractive surprise in up to 10% of patients.<sup>9</sup> Toric IOLs may rotate after implantation, with most rotating <5° postoperatively.<sup>10</sup> With every degree of rotation displaced, the toric lens loses 3.3% of its astigmatism-correcting power.<sup>11</sup> Manufacturer

lens errors may also provide a source of unexpected refractive outcomes. According to the international standard, spherical power may range 0.4D for lenses with power between 15 and 25D.<sup>12</sup>

This study provided interesting results, with both Resident A's and Resident B's mean SIA values falling in the accepted range of 0.30 to 0.50D.<sup>7,13</sup> The results of Resident A and B were not markedly larger than the proposed centroid value of 0.12D suggested by Warren Hill.<sup>14</sup> The results showed no statistical difference between the IOLMaster and Pentacam for both residents in terms of mean SIA and centroid values.

There are several limitations of this study, including the high rate of failure to follow-up. COVID-19 occurred during the study and caused 13 patients (18 eyes) of the 60 surgeries performed by Resident B and all of Resident C's patients to not follow-up. It was assumed that all temporal incisions were performed at the 180° axis and the 0° axis for right and left eyes, respectively. Another limitation of this study is the lack of standard to compare the residents' mean

SIA and centroid values to that of an experienced surgeon as a control.

No study to date has looked at SIA values performed by residents. Although the resident centroid values were either near or slightly above what other studies have shown for experienced surgeons, it is still felt that residents should continue using the proposed centroid value of 0.12D. With other areas of potential error, such as poor preoperative keratometry measurements, lens rotation, and the accepted range of manufacturer error of intraocular lenses, it is felt that SIA does not pose as much of a risk for refractive surprise following cataract surgery. Residents have been shown to have successful outcomes following toric IOL implantation, with one study out of the University of Texas Southwestern showing that resident toric IOL cases result in a mean refractive cylinder of 0.38D.<sup>15</sup> All residents are encouraged to calculate their own personal SIA for the most accurate refractive outcomes.

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